

Claims

What is claimed is:

1. A device, comprising:

5           an optical resonator designed to support whispering  
gallery modes and formed of a dielectric material that has an  
energy level structure that absorbs light at a selected optical  
frequency and absorbs electrical energy at an electrical  
frequency, wherein absorption of said electrical energy changes  
absorption of said light;

10           an optical coupler positioned adjacent to said optical  
resonator to evanescently couple optical energy into said  
optical resonator in a whispering gallery mode or out of said  
optical resonator; and

15           an electrical coupler positioned to couple an  
electrical signal at said electrical frequency into said optical  
resonator to at least partially overlap with said whispering  
gallery mode to modulate optical energy in said optical  
resonator by modulating said absorption.

20           2. The device as in claim 1, wherein said energy structure  
includes first, second, and third different energy levels to  
allow for (1) at least one optical transition between the first  
and said second energy levels at said selected optical frequency

and (2) an electronic transition between said second and said third energy levels in resonance with said electrical frequency.

3. The device as in claim 2, wherein a relaxation between said second and said third energy levels is substantially less than a rate of optical absorption in said one optical transition.

4. The device as in claim 2, wherein said first energy level is an excited state and said second and said third energy levels are ground states.

5. The device as in claim 4, wherein said second and said third energy levels are two different hyperfine energy splitting levels of a common energy level.

6. The device as in claim 5, further comprising a tuning mechanism to adjust an energy difference between said second and said third energy levels.

7. The device as in claim 6, wherein said tuning mechanism includes a mechanism operable to produce a tunable magnetic field at said optical resonator.

8. The device as in claim 1, wherein said dielectric material is doped with transition ions.

9. The device as in claim 8, wherein said transition ions  
5 include chromium.

10. The device as in claim 8, wherein said transition ions includes iron.

11. The device as in claim 8, wherein said transition ions  
10 include manganese.

12. The device as in claim 8, wherein said dielectric material includes a crystal.

13. The device as in claim 8, wherein said dielectric material includes a glass.

14. The device as in claim 8, wherein said dielectric  
20 material is further doped with ions that affect a net magnetic field at each transition ion.

15. The device as in claim 1, wherein said dielectric material includes a ruby doped with transition ions.

16. The device as in claim 15, wherein said transition ions include chromium.

5 17. The device as in claim 1, wherein said dielectric material exhibits an electro-optic effect to change a refractive index in response to an electric field.

10 18. The device as in claim 1, wherein said optical resonator include a spherical portion of a sphere.

15 19. The device as in claim 18, wherein said spherical portion includes an equator of said sphere.

20 20. The device as in claim 18, wherein said optical resonator has a disk shape.

25 21. The device as in claim 18, wherein said optical resonator has a ring shape.

30 22. The device as in claim 1, wherein said optical resonator is a sphere.

23. The device as in claim 1, wherein said optical resonator has a non-spherical shape.

24. The device as in claim 1, wherein said optical coupler  
5 includes a prism.

25. The device as in claim 1, wherein said optical coupler includes an angle-polished waveguide.

26. The device as in claim 25, wherein said waveguide is a  
10 fiber.

27. The device as in claim 25, wherein said waveguide is a  
15 planar waveguide formed on a substrate.

28. The device as in claim 1, wherein said optical coupler  
includes an input coupler and an output coupler.

29. The device as in claim 1, wherein said optical coupler  
20 is operable to produce an optical output from said optical resonator.

30. The device as in claim 29, further comprising an optical detector coupled to convert said optical output into an electronic signal.

5 31. The device as in claim 29, further comprising an optical device coupled to receive said optical output.

32. The device as in claim 29, wherein said optical device includes a fiber.

0 33. The device as in claim 1, wherein said electrical coupler includes an electrical wave cavity that at least partially encloses said optical resonator.

5 34. The device as in claim 1, wherein said electrical coupler includes electrodes.

35. The device as in claim 1, further comprising a signal generator operable to generate said electrical signal.

20 36. The device as in claim 1, further comprising an antenna operable to convert an electromagnetic wave into said electrical signal.

37. The device as in claim 1, further comprising a light source operable to produce said light.

38. A wireless communication system, comprising a plurality  
5 wireless transceivers, at least one transceiver including:

an antenna to receive an electromagnetic wave signal at an electrical frequency;

a light source to produce light at a selected optical frequency;

0 an optical resonator designed to support whispering gallery modes and formed of a dielectric material that has an energy level structure that absorbs light at said selected optical frequency and absorbs electrical energy at said electrical frequency, wherein absorption of said electrical  
5 energy changes absorption of said light;

an optical coupler positioned adjacent to said optical resonator to evanescently couple optical energy into said optical resonator in a whispering gallery mode or out of said optical resonator; and

20 an electrical coupler coupled to receive said electromagnetic wave signal from said antenna and positioned to couple said electromagnetic wave signal into said optical resonator to at least partially overlap with said whispering

gallery mode to modulate optical energy in said optical resonator by modulating said absorption.

39. The system as in claim 38, further comprising a  
5 satellite on which said one transceiver is located.

40. The system as in claim 38, wherein said one transceiver is a base station.

41. The system as in claim 38, wherein said one transceiver  
is a moving unit.

42. A communication system, comprising:  
an electronic communication system operable to  
transfer information on electrical signals;  
an optical communication system operable to transfer  
information on optical signals; and

an interface between said electronic communication  
system and said optical communication system, said interface  
20 comprising:

a light source to produce light at a selected optical frequency,

an optical resonator designed to support whispering gallery modes and formed of a dielectric material that has an



energy level structure that absorbs light at said selected  
optical frequency and absorbs electrical energy at an electrical  
frequency supported by said electronic communication system,  
wherein absorption of said electrical energy changes absorption  
5 of said light,

an optical coupler positioned adjacent to said optical  
resonator to evanescently couple optical energy into said  
optical resonator in a whispering gallery mode or out of said  
optical resonator, and

an electrical coupler coupled to receive an electrical  
signal from said electronic communication system and positioned  
to couple said electrical signal into said optical resonator to  
at least partially overlap with said whispering gallery mode to  
modulate optical energy in said optical resonator by modulating  
said absorption,

wherein said optical coupler further couples modulated  
optical energy out of said optical resonator into said optical  
communication system.

43. The system as in claim 42, wherein said optical  
communication system includes a free space system.

44. The system as in claim 42, wherein said optical  
communication system includes a fiber system.

45. The system as in claim 42, wherein said electronic communication system include a wireless system.

5        46. The system as in claim 42, wherein said electronic communication system includes a wired system.

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